

Topology of gold nanoparticle distribution and optical properties of opal-based metal-dielectric photonic crystals

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So far no omnidirectional photonic bandgap (PBG) in the visible have been achieved with metal-dielectric (MD) photonic crystals (PhCs). Here we summarize our observations of opal-based 3D MD PhCs containing Au nanoparticles comparing opals from Au nanoshells, opals with interstitial Au nanoshells and inverted opals from Au nanoparticles and outline their prospects.

In all cases, reflectance spectra exhibit the surface plasmon (SP) resonance and the diffraction resonance. We found that achieving the goal of modifying the diffraction resonance requires (i) formation of metal nanoshells and (ii) overlap of diffraction and nanoshell SP resonances. In the Au nanoparticle inverted opal, the SP and diffraction resonances cannot interact because nanoparticles themselves are not involved in scattering at PBG relevant frequencies. Alternatively, if the SP resonance in nanoshells does not overlap with the diffraction resonance, the PBG structure remains similar to that of all-dielectric opal with the dielectric constant modified by Au nanoparticles. The anti-crossing of diffraction and nanoshell SP resonances has been observed when Au nanoshells become major scatterers comprising the PhC lattice. In this case, specific excitations in the PBG frequency range will probably occur due to the high polarizability of nanoshells.